ORIGINAL RESEARCH

Diagnostic value of cervical vascular ultrasound combined with CT angiography in carotid artery plaque in patients with cerebral infarction

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Abstract

Objective

To clarify diagnostic value of cervical vascular ultrasound (CVUS) combined with CT angiography (CTA) in carotid artery plaque in patients with cerebral infarction.

Methods

A total of 110 patients with cerebral infarction upon admission to our hospital from January 2021 to December 2023 received enrollment and performed CVUS and CTA examination. Digital subtraction angiography (DSA) received application as the gold standard to compare the diagnostic efficiency of different detection methods.

Results

DSA examination was performed on the bilateral carotid arteries (220 carotid arteries) of 110 patients, and 194 plaques were detected, including 73 soft plaques, 93 hard plaques and 28 mixed plaques. A total of 174 carotid artery stenosis cases were detected, including 73 mild stenosis cases, 42 moderate stenosis cases, 36 severe stenosis cases and 23 complete stenosis cases. The accuracy rate of CVUS combined with CTA in detecting carotid artery plaque was 93.81% (182/194), higher than that of CVUS (75.77%, 147/194) and CTA (76.80%, 149/194), with significance ($P<0.05$). The accuracy of CVUS combined with CTA in detecting carotid artery stenosis was 94.83% (165/174) higher than that of CVUS (78.74%, 137/174) and CTA (84.48%, 147/174), with significance ($P<0.05$).

Conclusion

CVUS combined with CTA has a high diagnostic accuracy for carotid artery plaque lesions in patients with cerebral infarction, providing the basis for clinical diagnosis and follow-up treatment.

Keywords: cerebral infarction, carotid artery plaque, cervical vascular ultrasound, CT angiography

Introduction

Cerebral infarction is a common neurological disease with high morbidity and mortality; meanwhile, it is also an important cause of cerebral circulation disorder, diffuse or local brain function damage[1]. Cerebral infarction mostly occurs in the middle-aged and elderly , which is characterized by sudden onset, serious illness, rapid development, can damage the patient's nervous system, and can lead to death in severe cases, so clinical attention should be paid to it, so as to achieve early detection, early diagnosis and treatment[2].

Carotid atherosclerosis is an independent risk element for cerebral infarction, carotid plaque is major sign of carotid atherosclerosis, which is earlier than the cerebral artery and coronary artery lesions in the brain, which is conducive to early clinical detection of patients with lesions[3]. Cervical vascular ultrasound (CVUS) is a commonly used blood flow velocity and orientation measurement method, which can be performed at the bedside[4]. It is characterized by immediate, non-invasive, intuitive, low cost, repeatable use, etc., which is more acceptable to patients[5]. CT angiography (CTA) can qualitatively and quantitatively analyze the blood vessels of the head and neck of patients, clearly reflect the location, size and nature of the carotid plaque of patients, and help clinical early detection of the plaque in the blood vessels[6]. There have been relevant studies on CTA and cervical vascular ultrasound in the past, but there are few reports on the combined detection of carotid plaque.

Therefore, our study was designed to elucidate diagnostic value of CVUS in combination with CTA in carotid artery plaque in with cerebral infarction patients.

Data and methods

General data

A total of 110 patients with cerebral infarction upon admission to our hospital from January 2021 to December 2023 received enrollment, including 60 males and 50 females, aged 51-78 years old, with mean age of (68.23±6.43) years. There were 30 cases of hyperlipidemia, 25 cases of diabetes, and 46 cases of hypertension. All patients were informed of study content and signed informed consent. Inclusion criteria: (1) First onset; (2) There were no contraindications for cervical vascular ultrasound and CTA, and the diagnosis was confirmed by digital subtraction angiography. Exclusion criteria: (1) Patients with malignant tumors; (2) Incomplete clinical data; (3) Poor compliance; (4) Patients allergic to contrast agent.

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Methods

All the selected patients underwent CVUS and CTA examinations as follows:

(1) CVUS examination: The instrument was Philips IU22 Doppler ultrasonic diagnostic instrument with probe frequency range of (3 ~ 9) MHz. Vasoactive drugs were not allowed for 3 days prior to the test. During the test, the patient was in a supine position with a pillow placed behind the neck and the head tilted back so that the test site was completely exposed. The carotid arteries were scanned longitudinally and longitudinally on both sides, the long axial section of the internal carotid artery was shown, and the probe was slightly tilted outward, so that the bifurcation of the carotid artery, the external carotid artery, the common carotid artery, and the intracranial section of the internal carotid artery were ultrasonically examined. On this basis, the plaque in the upper cortex of the coronary artery wall was observed morphologically. First, a two-dimensional ultrasound examination was performed. The direction of the blood vessels was scanned from the bottom up to see the condition of the inner wall of the lumen, determine whether there was any abnormal echo, and determine the internal diameter of the artery. Blood flow in the arteries was monitored in all directions using Doppler ultrasound to determine if there are distortions, narrowing, plaques, and blockages. Carotid plaque could be identified if the carotid intima-media thickness was greater than 1.2 mm and the carotid artery was elevated.

(2) CTA examination: The scanning instrument was Siemens 64-slice spiral CT. The patient was placed in a lying position with shoulders down and no swallowing activity was allowed during the examination. Iopamidol was injected intraventically into the elbow of the patient with a high-pressure syringe at a rate of 3 ~ 4 mL/s, from the foot to the head, from the aortic arch to the Wills arterial ring at the base of the skull. The tube voltage was set at 120 kV, the layer distance was 0.45 mm, and the layer thickness was 0.9 mm. The width of the collimator of the detector was arranged at 64× 0.625 mm, and the image was reconstructed on the post-processing workstation. The layer spacing was 2.0 mm and the layer thickness was 2.0 mm. Based on the lesion detection of cross-sectional images, a variety of post-processing reconstruction techniques were used to process the images. Local vascular wall thickening and local lumen narrowing suggested carotid plaque.

(3) DSA examination: Axion Artis dTA angiography machine (Siemens) was used. The patient was placed in a supine position and exposed to both sides of the groin area. After disinfection, local anesthesia was administered with 2% lidocaine hydrochloride. Sledinger technique was used to place 5F catheter sheath and send it through 5F double-J tube guided by catheter sheath. Common carotid artery, aortic arch, intracranial artery, subclavian artery, and vertebral artery were respectively performed to observe and record luminal plaque and stenosis.

Evaluation criteria

(1) CVUS: Plaque: local bulge of the blood vessel wall, carotid intima-media thickness (IMT) ≥ 1.2 mm, in which soft plaque: the echo of the blood vessel wall was higher than the echo of the plaque, no sound shadow was in the rear; Hard plaque: the echo of the blood vessel wall was lower than or close to the plaque echo, and the sound shadow could be seen behind; Mixed patch: Low and high echo could be seen within the patch, with or without sound shadow presented behind.

Degree of carotid artery stenosis: mild stenosis: stenosis rate <50%; Moderate stenosis: the stenosis rate was 50% to 69%; Severe stenosis: stenosis rate of 70% ~ 99%; Complete stenosis: Stenosis rate was 100%.

(2) CTA: Soft plaque: rich lipid echo, CT value <60 Hu; Hard plaque: calcified high-density shadow could be seen in the plaque, CT value >120 Hu; Mixed plaque: The plaque density was mixed, and the CT value was 60 ~ 120 Hu.

Degree of carotid artery stenosis: assessed according to the North American Standards for Symptomatic Carotid Endarterectomy (NASCET) 7: mild stenosis: stenosis rate <30%; Moderate stenosis: the stenosis rate ranged from 30% to 69%; Severe stenosis: stenosis rate of 70% ~ 99%; Complete stenosis: Stenosis rate was 100%.

Observation indicators

Digital subtraction angiography (DSA) was used as the gold diagnostic standard to record the detection of carotid

Table 1 CVUS results of carotid plaque detection

CVUS	DSA		
	Soft plaque	Hard plaque	Mixed plaque
Soft plaque	54	7	5
Hard plaque	7	76	6
Mixed plaque	12	10	17
Total	73	93	28

Table 2 CTA results of carotid plaque detection

CTA	DSA		
	Soft plaque	Hard plaque	Mixed plaque
Soft plaque	56	9	7
Hard plaque	9	78	6
Mixed plaque	8	6	15
Total	73	93	28

Table 3 CVUS combined with CTA results of carotid plaque detection

CVUS combined with CTA	DSA		
	Soft plaque	Hard plaque	Mixed plaque
Soft plaque	67	2	1
Hard plaque	2	89	1
Mixed plaque	4	2	26
Total	73	93	28

Table 4 CVUS results of carotid stenosis

CVUS	DSA			
	Mild stenosis	Moderate stenosis	Severe stenosis	Complete stenosis
Mild stenosis	60	7	2	1
Moderate stenosis	9	32	4	1
Severe stenosis	3	2	27	3
Complete stenosis	1	1	3	18
Total	73	42	36	23

Table 5 CTA results of carotid stenosis

CVUS	DSA			
	Mild stenosis	Moderate stenosis	Severe stenosis	Complete stenosis
Mild stenosis	63	5	1	1
Moderate stenosis	7	35	5	0
Severe stenosis	2	2	30	3
Complete stenosis	1	0	0	19
Total	73	42	36	23

Table 6 CVUS combined with CTA results of carotid stenosis

CVUS	DSA			
	Mild stenosis	Moderate stenosis	Severe stenosis	Complete stenosis
Mild stenosis	69	2	0	0
Moderate stenosis	4	40	0	0
Severe stenosis	0	0	34	2
Complete stenosis	0	0	2	21
Total	73	42	36	23

plaque, vessel stenosis and different types of plaque after CVUS and CTA alone and combined examination, and to evaluate the diagnostic efficacy of single examination and combined examination.

Statistical analysis

SPSS 23.0 statistical software was used to process the data. The statistical data were expressed as (n, %) and compared using $\chi 2$ test. $P<0.05$ meant that the difference was statistically significant.

Results

DSA examination result

DSA examination was performed on the bilateral carotid arteries (220 carotid arteries) of 110 patients, and 194 plaques were detected, including 73 soft plaques, 93 hard plaques and 28 mixed plaques. A total of 174 carotid artery stenosis cases were detected, with 73 cases in mild stenosis, 42 cases in moderate stenosis, 36 cases in severe stenosis and 23 cases in complete stenosis.

Carotid plaque detection results

The accuracy rate of CVUS combined with CTA in detecting carotid artery plaque was 93.81% (182/194), which was higher than that of CVUS (75.77%, 147/194) or CTA (76.80%, 149/194) alone, implying a marked statistical difference ($P<0.05$, Table 1-3).

Carotid stenosis detection results

The accuracy of CVUS combined with CTA in detecting carotid artery stenosis was 94.83% (165/174), which was higher than that of CVUS (78.74%, 137/174) or CTA (84.48%, 147/174) alone, implying a marked statistical difference ($P<0.05$, Table 4-6).

Discussion

At present, the etiology of cerebral infarction is not clear, and the analysis may be related to the obstruction of blood and oxygen supply in the brain caused by atherosclerosis[8]. The rupture of the unstable plaque causes platelets to accumulate on it, and when the clot falls off, it can cause a blockage of the blood vessels in the distal part of the brain, leading to a cerebral infarction[9]. Atherosclerotic plaque is an important risk factor for cerebral infarction and is closely related to the development of the disease[10]. The higher the degree of carotid atherosclerosis, the greater the risk of morbidity and the more serious the disease is[11]. The main reason is that carotid artery stenosis caused by carotid plaque will lead to insufficient blood circulation in the cerebral vessels, causing cerebral atherosclerosis and then inducing ischemic encephalopathy[12]. Because the neck artery is shallow and easy to see, it is a key window to look for arterial disease and is the most prone place in the cerebrovascular system to narrow[13]. Some scholars believe that early detection of carotid artery stenosis and timely treatment can reduce the disability rate and fatality rate of cerebral infarction patients to a certain extent[14].

DSA is the gold standard for clinical diagnosis of carotid artery stenosis, which can clearly show the composition and degree of arterial plaque, etc.[15]. However, this examination is an invasive examination with high risk and is not suitable for patients with poor body status, liver and kidney dysfunction, and severe bleeding tendency[16]. Moreover, the operation is more complicated, and the examination cost is high, which is not easy for patients to accept[17]. Therefore, it is particularly important to seek other more efficient and non-invasive methods of examination.

The CVUS has the advantages of strong repeatability and can indicate the hemodynamic changes of blood vessels and lumen conditions by collecting the audio signal waveform and blood flow image of blood flow[18]. The pathological basis of cerebral infarction and carotid stenosis includes carotid intima thickening, atherosclerosis, arterial plaque formation, and lumen stenosis. CVUS exerts a vital role in evaluation and diagnosis of carotid atherosclerosis and carotid stenosis. CVUS can clearly depict whether intima-media is thickened, and can effectively detect intima-media thickness, providing data support for clinical evaluation of cerebral infarction. The limitation of CVUS is that it cannot detect carotid blindness, especially for patients with high straddle carotid balls[19]. The eddy current caused by carotid reflux, specific anatomical location, and operator's technique may also interfere with the diagnosis of carotid plaque[20].

Through three-dimensional reconstruction, CTA can observe blood vessels from different levels, directions and angles, and has high spatial and temporal resolution, avoid structural overlap, and can accurately evaluate carotid artery stenosis[21]. CTA, with its advantages of fast scanning speed and short imaging time, has received wide application in clinical diagnosis and treatment of head and neck lesions; CTA can clearly display morphological structure, plaque distribution, and composition of head and neck arteries through post-processing techniques, thereby more accurately evaluating characteristics of plaques. However, CTA cannot reflect the biological characteristics of neovascularization, inflammation, ulcers, etc., and cannot reflect the volume and hemodynamic characteristics of plaques[22]. According to the advantages and disadvantages of CVUS and CTA, some scholars believe that the combination of the two can complement each other, give full play to the advantages of the two examination methods, and improve the clinical diagnosis accuracy of carotid plaque, so as to provide important reference information for clinical diagnosis and treatment of diseases[23].

The results of our study revealed that the accuracy of CVUS combined with CTA in detecting carotid plaque and carotid artery stenosis was higher than that of CVUS or CTA alone, suggesting that the CVUS combined with CTA demonstrated high accuracy in diagnosing carotid artery plaque lesions in patients with cerebral infarction, exerting great clinical significance in cerebral infarction diagnostics. The reason is that CVUS can determine the thickness of endo-media, the degree of vascular stenosis, and determine the patchiness[24]. At the same time, it can also show the situation of new blood vessels in the plaque, which can further evaluate the risk of plaque, and then determine the situation of carotid artery stenosis, and show whether the carotid artery has plaque and the nature of plaque[25]. CTA can comprehensively evaluate the carotid artery system and help to understand the specific distribution of plaque and stenosis[26]. In our research, combined application of CVUS and CTA complemented each other, observing morphological characteristics of multiple extracranial vessels of carotid artery from different levels, angles, and directions, and clearly displaying the structure of vessel wall and abnormal blood flow in narrowed area. This suggests that CVUS combined with CTA can play a complementary advantage to further improve the detection rate of carotid plaque formation and carotid artery stenosis, facilitate the early detection of carotid artery stenosis, provide a reference for clinical treatment measures, and help control the progression of cerebral infarction.

Conclusion

CVUS combined with CTA has a high diagnostic accuracy for carotid artery plaque lesions in patients with cerebral infarction, providing the basis for clinical diagnosis and follow-up treatment.

Declarations

Funding

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Conflicts of interests

The authors declared no conflict of interest.

Availability of data and material

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical consideration

All assays received performance in compliance with the Helsinki Declaration criteria, and this study received authorization by the Ethics Committee of Kunshan integrated TCM and Western Medicine Hospital. All patients signed a documented, voluntarily informed consent form.

Author contribution

Jingjiao Qian conceived and designed experiments. Hanwen Shi contributed markedly to experiments and arranging data. Pingping Ye, Danni Wang, Xiaojuan Zhou and Linfeng Tang conducted data analysis. Guang Yang wrote draft manuscript. Guang Yang revised manuscript. All authors read and approved final manuscript.

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